**Enhancing communities’ adaptive capacity to climate change in drought-prone hotspots of the Blue Nile Basin in Ethiopia**

**ILRI-UNEP-Wollo University pilot project**

**TRAINING MANUAL ON HIGH LAND FRUIT AND VEGETABLE PRODUCTION**

**PRPARED FOR EXTENSION WORKERS AND FARMERS**

**AT KABE WATERSHED**

**ETHIOPIA**

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The authors

# PART I

# VEGETABLE CROPS PRODUCTION

1. **INTRODUCTION**

One of the approaches to cope up climate change is diversification of agricultural production. In the integrated approach of kabe watershed homegradening was one of the approaches based on prior need assessment studies. In the home garden intervention, high land fruit (apple) and different vegetable crops were introduced. In order to accomplish the task successfully capacity building training program had been given to Wereilu Wereda extension workers and farmers of the project area (Kabe). Apple, potato, garlic, shallot, carrot, cabbage and Swiss chard were the crops introduced during the home garden intervention.

Most of the Ethiopian population, residing in the rural area, is engaged in agricultural production as a major means of livelihood. However, the agricultural productivity is low due to use of low level of improved agricultural technologies, risks associated with weather conditions, diseases and pests, etc. Moreover, due to the ever-increasing population pressure, the land holding per household is declining leading to low level of production to meet the consumption requirement of the households. Production conditions in Ethiopia favour the cultivation of a wide variety of fruits and vegetables. Given the diverse range of altitudes in combination with irrigation potentials in different parts of the country, it is possible to produce virtually all tropical, sub-tropical and temperate horticultural crops.

Eventhough 85% of the livelihood of our country is dependent on agriculture , the production and productivity of the agriculture sector was insignificant. It was also difficult to supply raw materials for industries and in addition the production was of poor quality and quantity to supply the available agro industries and even for export purpose. So inorder to achive our objectives and to advance the agriculture sector it is necessary to implement different extension and trainings on these economocally important creops.

Vegetables are important crops in improving the livelihood of the people through supply of balanced diet thereby improving the health status of the people and as cash crop in generating income. Now a days our country is following an agriculture lead development industrilization policy and giving priority to the agriculture sector. The production of economically important cash horticultural crops has also given due consideration in the present govrnment policy. In order to achive the objective of improving the livelihood of the rural people, and to attract investors and make them profitable it is advisable to follow the extension pakage of this sector.

Exports of vegetable products from Ethiopia have increased from 25,300 tons in 2002/03 to 63,140 tons in 2009/10. Value of the fruit and vegetable exports increased with an average of 18% during this period from less than USD 10 to 30 million. Positive is also that the average value per ton of exported product increased at the same time. Table 3 below summarizes the main export trends in the Ethiopian fruit and vegetable sector.

In order to achieve the food security of our fast growing population, and to improve production and productivity of crops, different extension packages should be implemented. By doing this, it is possible to supply balanced food crops to our society. Vegetable and food crops supply essential elements (vitamin, minerals, protein and carbohydrates) to our body. So such crops are important especially to deliver the essential elements which we cannot get by eating other food items. Therefore, consumption of fruits and vegetables regularly is important to detoxify the acid foods produced by eating animal food items. In addition these crops are also important to improve the livelihood of the society (the producers) as they are cash crops.

Most of our farmers are dependent on rainfed system of production, and rainfall pattern is more or less erratic which has direct impact on the quality and quantity of the produce. So this has always lead to food insecurity and food starvation to our people. By producing root crops, which can resist harsh environmental conditions, like cassava, enset, sweet potato, using improved production systems; it is possible to achieve food security. 

**Objectives**

* to make aware of the importance of vegetables
* to extend production technologies of individual crops listed so as our farmers will produce vegetables in quantity and quality
* to have access to get vegetables for supplying balanced diet
* to supply raw materials for agro industries
* to solve the problem of food insecurity by maximizing production per unit area
* to use as a training manual for Woreda expertise, development agents and farmers who are engaged in the production of high land fruits (apple)
* to use as a practical guide line about how to propagate, establish and manage high land fruit crops (apple) for investors, experts, and development agents.

**Vegetable crops grown in the highlands and mid altitude of Ethiopia, which are discussed under this module are**

1. Potato
2. Shallot, onion and Garlic
3. Leafy vegetables: lettuce, cabbage …..
4. Carrot
5. Beet root

**Points to be discussed under each vegetable crop**

1. Description of the plant

2. Ecological requirement of the plant

3. Propagation methods and planting

4. Management practices of the crop

5. Harvesting and post harvest handling of the crop

**1.1 WHAT ARE VEGETABLES?**

**Definition of vegetables**

* **Vegetables** are any herbaceous (non-woody) plants whose fruit, seeds roots tubers, bulbs, stems, leaves or flower parts are used as food and are usually grown as annuals (in many cases)and as perennials (in rare cases, such as Asparagus).
* Biennials such as carrot are grown as annuals in tropical areas because it is consumed before the formation of flower & seed.
* Or **vegetables** are those plants which are consumed in relatively small quantities as a side- dish or a relish with the staple food.
* Or a **vegetable** may be defined as the edible portion of an herbaceous plant used fresh or processed.
* Or **Vegetables** are horticultural food crops grown in most cases as annuals and a few cases as perennials. Most plants are herbaceous and not woody. Plant parts used for food can be: roots, stems, tubers, immature seeds, leaves, immature fruits, mature fruits, flowers
  1. **IMPORTANCE OF VEGETABLE CROPS IN GENERAL AND IN ETHIOPIA IN PARTICULAR**

**1.Vegetables as a source of vitamins**

Carotene, a precursor of vitamin A, is abundant in several vegetables such as carrots, sweet potatoes, spinach, lettuce, amaranths, kale, turnip greens muskmelon and watermelon. It is also found in raw tomatoes, cabbage and green peppers. Vitamin C is abundant in many vegetables - kale, Brussels sprouts, broccoli, lettuce, tomatoes, peppers, potatoes, cabbage, greens, cucumber, bitter gourd and onion, especially when they are uncooked.

**2.Vegetables as a source of minerals**

Vegetables are important sources of the minerals that are essential for proper growth and development. Potato, sweet potato and onion contain appreciable amounts of phosphorus. Calcium is present in spinach, beans, lettuce, onions, tomatoes and varieties of the cabbage family such as head cab­bage, cauliflower, broccoli, and kale and collard greens. Soyabean, spinach, peas, chillies, radish, garlic, beans and tomato are good sources of iron. Veget­ables like onion, okra and asparagus provide iodine. In general, legumes contain more iron, calcium and potassium salts. Calcium, magnesium and potassium act as neutralisers of acids which are produced in the course of digestion of meat, cheese and other foods.

**3. Vegetables as a source of roughage**

Most vegetables have a high percentage of roughage, i.e. indigestible cellulose material. Although of no direct nutritional value, the presence of this material in the human digestive system is, nevertheless, of considerable value. Not only does the spongy mass help to satisfy the petite, but it also assists in moving food through the alimentary canal by aiding the muscular action of the intestine, thus preventing constipation.

**4. They are important in** **neutralizing the acid substances** produced in the course of digestion of heavy food stuff such as meat, cheese, and others which causes aging and leading to blader cancer, obesity, hypertention, cholesterol, heart tattack which is a problem of bloodcancer.

5. **Root crops are second only to the cereals as a staple food.**

Potatoes in Ireland, yams and cassava in some parts of West Africa and Southeast Asia, taro and sweet potatoes in the Pacific islands are examples.

**6. Import and Export**

Climatically as well as logistically, Ethiopia has potential for the production and export of different fresh and canned vegetables and flowers to lucrative markets in the Middle East and southern Europe. Increasing of processing industries in Ethiopia indicates the importance of vegetables in foreign currency. Production of processing tomatoes and conversion into valuable finished products has become an important branch of Ethiopian Agro-industry. The economic and social impact of tomato industry is not only limited to the value of the produce in local currency. After covering the local demand of canned tomato products, export markets are on the way to be opened with the respective earning of foreign currency. Furthermore, the incomes of thousands of families depend on the employments created by tomato production and processing. Substantial reductions of imports of horticultural products have taken place in the last few years through a systematic program of import substitution. Marmalades, puree, ketch up and jams manufactured by horticulture development co-corporation have found ready acceptance in the consumer market. There is considerable potential for the manufacture of a range of products that could be produced locally for horticultural commodities.

**6. Industries**

Most agro-industries are involved in the use of horticultural crops. To mention a few, fruit and vegetable processing and product manufacture like spice extraction, wines, sauces, ketchup, juices, marmalades, squashes and most of preserved foods are manufactured.

7. **Medicinal Value**

Most vegetables used for insect and disease control. For instance, garlic and capsicum varieties have important botanical effect on the control of African boll.

**8. Food and social Security**

Vegetable farms are profitable (production per ha.) and generate income source to farmers and creates job opportunity.

1. **TREND OF VEGETABLE PRODUCTION**

**Objectives**

* **To know the trend of vegetable production in in general and in Ethiopia in particular**
* **To aware of the challenges and prospects of vegetable production**

**Overview**

* Vegetables are the best resource for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and more jobs per hectare than staple crops.
* The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals.
* Amongst vegetable crops, tomatoes are the most important horticultural crop worldwide and grown on over 4 million hectares of land area
* Environmental stress is the primary cause of crop losses worldwide, reducing average yields for most crops by more than 50%
* The tropical vegetable production environment is a mixture of conditions that varies with season and region.
  1. **VEGETABLE PRODUCTION IN ETHIOPIA**

Although horticultural crops are important for health and economy the amount and mode of production is still weak in Ethiopia.. Horticultural crops can be differentiated as fruit (permanent crops) and vegetables (short season crops). Accordingly permanent crops are long term crops that occupy the field planted for a long period of time and largely harvested every year and do not have to be replanted for several years after each harvest.

Ethiopia has a variety of vegetable crops grown in different agro ecological zones produced through commercial as well as small farmers both as a source of income as well as food.. However, the type is limited to few crops and production is concentrated to some pocket areas. In spite of this, the production of vegetables varies from cultivating a few plants in the backyards for home consumption up to a large-scale production for domestic and export markets.

The productivity of crops is very low compared to the potential yield obtained in the research centers and on farmers’ field technology verification studies. For instance, the productivity of onion and tomatoes was about 90 and 70 quintals per hectare compared to the potential yield of 400 and 350 quintal per hectare in research centers.

Exports of vegetable products from Ethiopia have increased from 25,300 tons in 2002/03 to 63,140 tons in 2009/10. Value of the fruit and vegetable exports increased with an average of 18% during this period from less than USD 10 to 30 million. Positive is also that the average value per ton of exported product increased at the same time. Important export markets for vegetables are the surrounding countries (Djibouti, Somalia, and Sudan); the main products being non-graded fresh vegetables. Higher value fresh produce (including graded and pre-packed vegetables and fresh herbs) are exported to the United Kingdom, United Arab Emirates and the Netherlands. The main fruits exported are citrus, bananas and mangoes. Around 85% of the fruits are exported to Djibouti. The second market destination is the Emirates.

Vegetable production in the peasant sector is mainly rain fed, few are using irrigation. In state farms the total production of vegetables is irrigated. The annual fresh vegetables production is about 3 million tons, of which state farms share 1%. The major vegetable producers are small scale farmers. The loss of vegetables between production and consumption is estimated to 25-35%. This implies that the consumption of assorted vegetables amounts to 65-75% of the total fresh vegetables production of the country. Currently 95% of the fresh vegetable supplies to the domestic urban and regional export markets are sourced from the peasant sector

Encouraged by the Ethiopian Government’s policies of privatization and promotion of private commercial export production, a small number of private sector companies have evolved into the production, processing and export of F&V products since the early 1990s. Currently there are around 12 private commercial farms that are (partly) engaged in the production and export of fruits and/or vegetables.

## PROSPECTS AND CHALLENGES OF VEGETABLE PRODUCTION IN ETHIOPIA

**Prospect of vegetable crops production**

* Suitable agro climatic conditions
* Cheap labor sources
* High level of support by the government
* Proximity to global market areas
* Easily accessible organic products

**Constraints in the production of vegetable crops**

**bd14565_** Lack of quality seed and planting materials

bd14565_ Lack of appropriate production technology

* Capital and labour intensive
* Time sensitive and dynamic
* Lack of packaging and storage
* Lack of facilities in transport system
* Lack of skilled labour
* Rainfed system of production and most of the production is from the pesant farm
* Cereal focused research and extension
* Exploitation by middle men
* Low consumption
* Post-harvest losses ( highly perishable because of high rate of respiration)
* Marketing

**POSSIBLE RECOMMENDATIONS**

* **Minimizing dependence on rain:**

Heavy or little rainfall, drought or shortage of irrigation water has repeatedly resulted in erratic yield losses. This can be overcome by installation of irrigation scheme in vegetable farms and its encouragement in peasant farms so that dependence on rainfall will be minimized.

* **Appropriate planning**:

Keeping the production supply according to the capacity of processing plants and the market demand

* **Giving necessary priorities** for horticultural crops research and development encourage market promotion and introduce the consumption habit of the society.
* **Correct technological defects**: Avoid use of inadequate production equipment both in cultivation and processing of commodities.
* **Develop communication** of peasant rural market with the main routes and improve transportation facilities in relation to perishable nature of vegetables.

In many parts of the world vegetable constitutes a larger part of the diet. Vegetable crops are vital sources of food. In some tropical countries, gardening is becoming a highly commercial venture, which can provide a source of hard currency.

**PER CAPITAL PRODUCTION AND EXPENDITURE OF VEGETABLES IN ETHIOPIA**

A recent study estimates the average annual per capita consumption of vegetables as 48kg for rural and 37 kg for urban population. The same study estimated the rural and urban per capita expenditure on vegetables as Birr 12 per annum and Birr 29, only 6% of the total annual expenditure for food, respectively. The urban consumption of fresh fruits and vegetables is estimated to be as low as 25-30% of that of Western World (130-160kg per capita).The consumption of canned fruits and vegetables by both the rural and urban population is close to zero. This low level of per capita consumption is accounted to:

1. the traditional eating habits of our population
2. the low level of per capita income
3. the high price of vegetables and fruits
4. less knowledge about vegetables
5. supply shortage of some preferred vegetables etc
6. **INDIVIDUAL VEGETABLES**

**Objectives**

* to make aware of the new production technologies of important vegetables
* to specifically advance the way of controlling pest and disease problems and therby increasing yield
  1. **POTATO**

**Description of the plant**

Family: Solanaceae

Potato is the fourth major food crop after rice, wheat and maize in the world. It produces the highest dry matter, well balanced protein and more calories/ unit area and time. *Solanum tuberosum* is a tuber bearing herbaceous perennial but is treated as an annual under cultivation. The aerial part of the stem is erect in the early stages of growth but latter it becomes more spreading

**Ecological requirement of the crop**

**Climate:** Though a temperate crop, potato is adapted to a range of climatic conditions. Most varieties perform well when days are sunny and nights are cool. In India potato crop is raised in areas and seasons when day and night temperatures are below 35°C and 20°C respectively.

* For sprouting and initial growth of plants, a temperature of 22-24°C is the best while for tuberization, a still lower temperature of 18-20°C and short days are ideal. Growth of plants is accelerated during long days and high temperature.
* For flowering, potato is a long day plant. Flowering takes place under cool climate and long day conditions of more than 15 hours light. Such conditions are available during summer months in the hills. Host varieties will not tuberise if night temperature is above 23°C.

**Soil:** Deep well drained alluvial soils with almost neutral reaction are best for potato cultivation.

* This is followed by hill, black and red soils. Soil should be loose, firm and without compacted layer that hinders root penetration.
* Compacted layers also restrict drainage. Soil should be free from stones and clods for avoiding deformation of tubers.

**Propagation and planting**

Potato can be propagated by its tuber or using true potato seeds. But the use of TPS is not recommended for commercial production of potato.

* Potato is propagated through tubers which have a dormancy of 8-10 weeks. Eyes on surface of tubers have axillary buds. Sprouted tubers when used for planting put up fast and vigorous growth.
* Nearly 40% of total production of potato cultivation is for seed tubers.
* Bulky nature of tubers is a problem for transportation and it increases seed cost considerably.
* Transmission of viral diseases through tubers is another disadvantage. To avoid above bottle-necks, the concept of true potato seed (TPS) was evolved.
* Potato is planted at a spacing of 20-30 cm between plants and 70-75 cm between rows with a depth of 5-8cm.
* the size of the tuber for planting is around 25-55mm in diameter, normally an egg size tuber is recommended.
* In case the size of planting tuber is large it can be cut in to pieces (two/three) each cut having a bud.

**Seed rate**: 18 quintals/ha if we use medium size tubers and 20Q/ha for large tubers

**Planting time**: starting from mid of June in our case, if we use rainfed system. If we use irrigation water planting should be at frost free periods, starting from January in our case

**Land preparation:**

* depending on the type of soil it requires three to four times plowing when the soil has good moisture content, this is to avoid the formation of large clods and to get good texture
* 25-30cm deep cultivation is required
* Mark the plot and dig the hole or make an open 10 cm depth
* It is good to apply fertilizer in bands, 5cm below the tuber (15 cm depth) and cover the fertilizer with soil in order not the tuber to come in direct contact with the fertilizer, and place the fertilizer also around the tuber (5-7cm away)
* No tuber part should be exposed to light

Fig. 1

**MANAGEMENT PRACTICES OF THE CROP**

**Manures and fertilizers**

* Potato is a heavy feeder and plants respond well to application of manures and fertilizers.
* Fertilizer recommendation vary with the type of soil and even with variety but generally 165KG/ha urea and 195KG/ha DAP is recommended.
* Manure is also important for potato production. It requires 200-400kg/ha of well decomposed compost.
* Tubers and flowers are considered as sink for the synthesized food and so the compute each other, so in order to reduce this competition removal of flowers is advisable to maximize yield

**IRRIGATION**

* Total water requirement for potato varies from 350-550 mm depending on soil type, crop duration and climate. A pre-planting irrigation is good for uniform germination.
* A second irrigation is given one week after and subsequent irrigations as and when required. Stolon formation, tuber initiation and development are critical stages of water requirement.
* Irrigation is stopped about 10 days before harvest to allow tuber skin to become firm.
* It requires watering/irrigation at 7-10 days interval at an early stage of development and frequent watering starting from flowering up to tuberization.

**Weeding and Cultivation**: it requires 2-4 times weeding and cultivation until the canopy covers the ground and able to smother weeds.

CULTIVATION:

* First earthingup, when the plants are 15-20cm. ridging can be done by extra soil from the neighbor but never cover the crop totally
* Second earthingup, 2-3weeks after the first earthingup
* Third earthingup, 2-3weeks after second earthingup
* Add extra soil during second and third earthingup

***Pests and disease management***

* Aphids and leaf hopper are important pests that transmit and spread a number of viral and mycoplasmal diseases.
* *Aphids* : During winter: and spring seasons, potato crop is attacked by a number of aphid species like *Myzus persicae, Aphis gossypii* and *A. labae.* Of these, M. *persicae* causes serious damage. Both nymphs and adults suck sap, of plants causing drying up of leaves.
* *jassid (Amrasca biguttula biguttula)* : Both nymphs and adults suck sap and result in typical hopper burn symptoms.
* For controlling aphids and jassids, spray of 300 ml of Dimethoate 30 EC or Metasystox in 80-100 litres of water.
* *Late blight (Phytophthora infestans)* : This is the most destructive disease of potato and causes significant loss in yield. Symptoms appear as small water soaked spots on tips, margin and other parts of plants which later enlarge to form irregular dark brown lesions.
* Control measures involve use of disease-free tubers, following high ridge cultivation, restricting irrigation during cloudy days, growing resistant varieties, spraying of Indofil M 45 or Kavach at weekly intervals.

Fig. 2

**Harvesting and Yield**

* The leaves or stem will turn to Yellow at maturity and harvesting should be 10-15 days after the stems and leaves dry, this is to prevent the tubers from bruising.
* It will be harvested 90-120days depending on varieties
* Harvesting of potato is done before temperature rises above 300C.
* Harvesting is done manually with help of a spade or bullock-driven single row plough.
* Average yield of early maturing varieties is 20 *t/ha* while that of late maturing varieties is 30 *t/ha.* Generally a yield of up to 100Mg/ha is recorded in some cases.

**Postharvest management of potato**

* Great care should be taken in handling of potatoes especially for seed purpose. Nearly one fifth of potato production in the country is utilized for planting in next season.
* After harvesting, tubers are kept in heaps in a cool place for 10-15 days for drying and curing of skin.
* Heaps of 3-4 m long and wide at base and 1 m central height is the best.
* In hills tubers are spread in well ventilated rooms. Later cut, damaged and rotten tubers are discarded and good tubers are graded into four sizes *viz.,* small (below 25 g), medium (25-50 g), large (50-75 g) and extra large (above 75 g).
* Potatoes for seed purpose are treated with 3% boric acid solution for 30 minutes for protection against soil borne diseases like black scurf, common scab etc before storing in bags.
* In indigenous method, seed tubers are stored in a single layer on sand.
* Frequent examination is necessary to discard tubers showing symptoms of rotting. Tubers are also stored in pit method. Here, pits of 60-75 cm depth 240 cm length and 90 cm width are made in cool shady places.
* Water is sprinkled inside the pit to cool it. After two days, pits are lined from inside with neem leaves, dry grass or sugarcane trash. Bamboo chimneys of 1.2 to 1.5 m length are placed inside the pit 1.2-1.5 m apart for escaping moisture due to evaporation of tubers.
* Pits are then filled with tubers upto 15 cm from top followed by a 30 cm layer of trash. A thatch is also provided over the pit as a protection from rain and sun.

Some of the available varieties of potato in Ethiopia

* Kulumsa , Chala, Digemegn , Gudanie, Hundee, Wechecha, Chiro, Guasa ,Jalanie ,Gera ,Gorobela and Belete
  1. **BEETROOT**

(Syn: Garden beet) , Family: Chenopodiaceae

**Description of the plant**

*(Beta vulgaris* L.) (2n = 2x = 18

Beet root is a popular root crop grown for its fleshy roots which are used as cooked vegetable, salad and for pickling and canning. Young plants along with tender leaves are also used as pot herbs. It is very popular in USA. Beet root is a rich source of protein (1.7 g/100 g), carbohydrates (88 mg), calcium (200 mg), phosphorus (55 mg) and vitamin-C (88 mg). Leaves are rich in iron (3.1 mg), vitamin-A (2100 I.U.), thiamine (110 µ g) and ascorbic acid (50 mg/ 100 g).

**Ecological requirement**

**Climate**

* Beet root is hardy to low temperature and prefers cool climate. Though it grows in warm weather, development of colour, texture, sugar content etc. of roots is the best under cool weather.
* High temperature causes zoning­ appearance of alternate light and dark red concentric rings in the root. Extreme low temperature of 4.5-10.00C for 15 days will results in bolting. It requires abundant sunshine for development of storage roots.

**Soil**

* Deep well drained loam or sandy loam is the best for beet root cultivation.
* Heavy clayey soils result in poor germination and stand of crop due to formation of a soil **crust** after rains or irrigation.
* Roots may be mis-shaped and will not develop properly in heavy soils.
* Beet root is highly sensitive to soil acidity and the ideal pH is 6-7. Beet root is one of a few vegetables which can be successfully grown in saline soils.

**Land preparation and sowing**

* Being a cool season crop, beet root is raised during winter in plains and as a spring-summer crop in hills by March-April. In plains, sowing is practised during September-November.
* Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed farmyard manure at the time of final ploughing.
* Flat beds or ridges and furrows are prepared. Water-soaked 'seed balls' which contain 2-6 seeds are drilled 2.5 cm deep in rows at a spacing of 45-60 x 8-10 cm. 5-6 kg of seeds is required for one hectare. Staggered sowing at 1-2 weeks interval ensures steady supply of roots during the season.

Fig. 4

**Manures and fertilizers**

* Well-rotted FYM at 50-60 t/ha should be incorporated during soil preparation, or preferably applied to the previous crop.
* On sandy soils, organic manure@ 25 t/ha is recommended. For an average soil, 60-70 kg N, 100-120 kg P and 60-70 kg K/ha is recommended.
* Entire farmyard manure, half of N and full P and K should be applied basal at the time of land preparation prior to sowing and remaining at 30-45 days after sowing.
* Nitrate sources of N are preferred to ammonium sources.
* Beets have a relatively high boron requirement and its deficiency causes internal breakdown as black rot or dry rot.
* Beets must make rapid and continuous growth to develop high quality; therefore a good supply of available N, P and K is necessary.

**Management of Beetroot**

* Thinning is an essential operation when more than one seedling germinate from each seed. Moist soil is essential for seed germination and for further growth.
* Usually 5-6 irrigations are usually given during summer and three irrigations during winter in North Indian plains.
* Field is usually kept weed-free by light hoeing at early stage of crop. Swollen roots are also to be covered with soil by **earthing up.**

**Harvesting**

* Medium sized tubers are of great demand and tubers are harvested after attaining a diameter of 3-5 cm.
* Harvesting is done 8-10 weeks after sowing by pulling the top with hand. Later tops are removed, graded and marketed.
* In European countries, where small sized bunches are in demand, tubers are tied in bundles of 4-6 with their tops. Over-matured and oversized tubers become woody and crack.
* Yield varies from 25 to 30t/ha and the tuber stores well at O°C and 90% RH.
  1. **CARROT**

**Description of the crop**

*(Daucus carota* L.) (2n = 2 x = 18)

Family: Apiaceae/Umbeliferae

Carrot is an ancient cool season root vegetable. Roots are used for making soups, stews, curries, pies, pickles and for salad purposes. Roots are also canned. Carrot roots are rich sources of β and α carotenes (1890 µ g/100g) and contain sucrose 10 times that of glucose or fructose. Carrot leaves are a good source of leaf protein. It is used as fodder and for preparation of poultry feeds. Carrot has many medicinal properties. It increases quantity of urine and helps in elimination of uric acid. It has cooling effect and is beneficial for people suffering from gall stones, constipation and heart troubles.

**Ecological requirement**

**Climate**

* Climatic and soil factors have great-influence on shape and colour development of roots. Ideal temperature for germination of seeds is 7.2-23.9°C, while for root growth and development it is 18.3-23.9°C.
* Tropical types produce roots even at a temperature of 250C. European types require a low temperature of 4.8 - 10.0°C for 4-6 weeks at any time during development of roots or after they mature either in storage or in field.
* Seed stalk formation takes place only when plants are subjected to a subsequent temperature of 12.2 - 21.1°C.

**Soil**

* Deep and well drained friable soil is essential for proper root development.
* For early crop, sandy loam and for heavy yield, silt loam is preferred.
* Long rooted cultivars perform the best in light soil. In heavy soils, short stump rooted varieties having round and heart-shaped roots are preferred. In hard soils, roots will be rough and coarse. The ideal soil pH is 6.6 - 7.1.

**Land preparation, sowing and manuring**

* Soil is ploughed to a fine tilth. Utmost care should be taken to remove clods, stones etc. Land is then made to ridges and furrows at 30-45 cm apart, in small plots of convenient size for irrigation.
* Seeds are sown on ridges or on flat beds either by dibbling in lines or by broadcasting.
* Seeds are first rubbed to remove fine hairs and mixed with fine sand before sowing to facilitate even distribution.
* For sowing in lines, a small furrow of about 1.5 cm deep is made at top or on either sides of ridges with finger or with sharp end of a stick.
* Seeds mixed with sand are dropped in furrow by hand and is covered lightly with soil.
* Seed rate varies from 6 to 10 kg/ha depending on variety and sowing. Seedlings should be thinned to a plant to plant distance of 5-8 cm, soon after they are established. Otherwise, overcrowding leads to **deformed roots.**
* It is advisable to give light irrigation immediately after sowing or to soak seeds in water for 12-24 hours before sowing to hasten germination.

Fig. 3

**Manuring/fertilization**

* In addition to 20-25 tones of farmyard manure
* Fertilizer dose of 80kg N, 40-50 kg P20S and 80-100 kg K20 is recommended for the crop, of which entire dose of farmyard manure, half N and full P and K are to be applied as basal dose at the time of final land preparation.
* Remaining dose of N can be applied at the time of first hoeing.

**Harvesting**

* Roots grown on ridges are usually harvested after loosening soil with a spade and by pulling out roots by grasping top. In flat ground, top is removed close to ground and roots are dug out with a spade.
* A light irrigation is usually given before harvesting for easy uprooting. Yield varies with season, climate, varieties etc.
* Tropical types yield 20-30 t/ha and European types yield 10-15 *t/ha.*
* Harvested roots are put in basket and dipped in flowing water for washing.
* Roots are then partially dried, trimmed and graded before sending to distant markets.
* Fresh Carrot roots can be stored for 3- 4 days under ordinary conditions and for six months at 0°C and 93-98% RH
  1. **GARLIC**

**Description of the crop**

*(Allium sativum* L.) (2n = 2x = 16)

Garlic resembles the onion except that it has flattened solid leaf blades and produces a compo­site or compound bulb, consisting of several small densely crowded, angular, tunicate bulblets or 'cloves' enclosed within the white or pink 'skin' of the parent bulb Each clove is de­rived from an axillary bud of the younger foliage leaf and consists of a protective cylindrical sheath, a single thickened storage leaf, and a small central bud.

**Ecological requirement**

**Climate**

* Garlic prefers cool climate as common onion.
* Excessive heat and long days are not suitable for bulb formation.
* Hence, the crop is usually planted during short days of winter to promote vegetative growth and harvested when hot season sets in.
* However, there are specific varieties suitable for long day condition.

**Soil**

* Just like onion, garlic requires well drained friable soil rich in humus.
* In heavy soil, bulbs will be deformed and results in broken and damaged bulbs, which do not store well in storage.

**Land preparation, planting and fertilization**

* Land is ploughed to a fine tilth by 4-5 plowings and leveled properly.
* Further preparation depends on method of planting. Generally three methods of planting are followed:
* *Dibbling:* Field is divided into small plots convenient for irrigation.

Cloves are dibbled 5.0-7.5 cm deep keeping their growing ends upward at a spacing of 15 x 10 cm.

* *Furrow planting:* Furrows are prepared with hand hoe and cloves are dropped into furrow by hand. They are then lightly covered with loose soil.
* *Broadcasting:* Cloves are broadcasted in a well prepared levelled land and covered by harrowing.
* Depending on method of planting, 500 to 600 kg of cloves are required to plant one hectare. Planting time varies from region to region.
* In plains, it is planted from August to November and in hills during March - April.
* Garlic is propagated vegetatively by a single clove.
* Bulbils are also occasionally used for planting.
* Storing bulb at 4°C for 1-2 months is helpful in breaking dormancy of cloves. Individual cloves are carefully separated from composite bulb without any injury.
* Bigger cloves of 8-10 mm diameter that too from outer side of bulb give high yield.

**Manure /fertilizers** **and irrigation**

* Farmyard manures @10-15 t/ha should be inc-orporated to soil at the time of initial ploughing.
* Fertilizer recommendation varies from region to region and ranges from 60-125 kg N, 35-65 kg P and upto 100 kg K /ha. Entire P and K along with half of N should be applied as basal dose.
* Remaining N may be applied at one month after planting. Excess N results in **thick neck and sprouting** before harvest. It also induces "**rubbering"** of cloves wherein, developing bulbs become spongy and rubber like. This is a physiological disorder and pathogenic infections are not seen associated. By judicious application of N, rubbefing can be avoided.
* Specific advantages of using micro-nutrients in garlic are reported from different parts. Magnesium sulphate (0.1 %), boric acid (0.2%), copper sulphate (0.02%) and zinc sulphate (0.02%) stimulate dry matter accumulation in cloves.
* Application of borax (0-10 kgfha) is beneficial for increasing bulb size and yield.
* Irrigate field immediately after sowing. Repeat irrigation 3 days after, for ensuring germination. Thereafter, irrigate once in a week during vegetative phase and 10-15 days during bulb development. Avoid irrigation during bulb maturity. irrigate 2-3 days before harvest to facilitate easy uprooting.

**Harvesting and yield**

* Crop is ready for harvest 4-6 months after planting.
* Maturity of bulbs is indicated by turning of tops to yellowish or brownish and drying. Bulbs are lifted and leaves are tied at top.
* They are cured for about a week in shade and stored. Tops are removed before marketing bulbs. Yield varies from 6-12 t/ha.

**Storage and marketing**

* Thoroughly cured bulbs can be stored moist free in ventilated rooms.
* Mould attack and root growth start at relative humidity above 70%. Cold storage of garlic at 0-2.2°C and 60-70% RH
* Depending on size, three grades *viz.,* big (30 mm diameter), medium (25 mm) and small (12 mm) are available in garlic.

## 3.5 SHALLOT

**Description of the crop**

***Allium cepa* L. (Aggregatum group)**

Shallots produce a cluster of bulbs from a single planted bulb. Otherwise, they are similar to the common onion. Commercially they are grown mainly for marketing as green onions, mainly in the South. The mother or "seed" bulbs are planted in late summer or fall. As daughter bulbs and plants develop, soil is pushed around them to blanch the lower portion. Daughter plants are pulled at suitable size, the outer skin removed from the bulb and base of leaves, and the small bulb and green leaves are marketed as green onions. Shallots are also grown for the dry bulbs, which are milder flavored than most onions. Culture for dry bulbs is essentially like that for onions.

**Ecological requirement**

* A temperature of 21-320c is required
* Sandy loam or loam soils are preferred, but shallots have been successfully produced on a wide range of soils.

**Propagation and plating**

* Using bulbs, they have at least 6weeks dormancy
* Sprouting is seen when dormancy is broken
* Planting at spacing of 25-30cm between rows and 12-15cm between plants
* Place in the prepared land by making an open at the distance and cover with soil

**Management of the crop**

**Fertilizer and irrigation**

* The following are general recommendations. It is advisable to use a soil test for each field to be planted.
* Nitrogen: 50 lb N/acre applied at planting time for fall planted fields. Apply an additional 60-90 lb N/acre in spring, or use that amount for spring planted fields.
* Apply water uniformly. Shallots are shallow rooted and benefit from frequent irrigation. Reduce irrigation as bulbs reach marketable size to reduce disease problems and facilitate curing.
* Soil type does not affect the amount of total water needed, but does dictate frequency of water application. Lighter soils need more frequent water applications, but less water applied per application.

**Disease control**

* Shallots are affected by many of the same diseases that affect onions. Fungicides registered for shallots, but not evaluated by University personnel in the Pacific Northwest, include Bravo, Ridomil, and Telone.
* Proper rotations, field selection, sanitation, spacing, fertilizer and irrigation practices can reduce the risk of many diseases.
* Fields can be tested for presence of harmful nematodes. Using seed from reputable sources reduces risk from "seed borne" diseases.
* Hot water treatment and Benlate for seed pieces for white rot control - same as garlic - but may need to reduce temperature.

**Harvesting, handling, and storage**

* Shallots may yield approximately 9-12 tons per acre. Harvest shallots when bulbs are fully mature, well colored, and 1-2 inches in diameter.
* Harvesting is done at 60-100days after planting
* Allow to cure in sacks, or bins, or under cover.
* Shallots are usually hand cleaned, topped and put into bags or bins for storage after the necks and bulbs are well cured.
* Shallots store well at temperatures of 32-35 F and 60-70% relative humidity. Because of their small size, shallots tend to pack closely; so they should not be place into deep piles.
* Store shallots on slatted crates or trays that allow good air movement in and around the bulbs. This is important to remove excessive moisture and to minimize storage diseases.
* Low relative humidity and low temperature are important to keep shallots sound and dormant and free from sprouting and root growth.

**Sprouting inhibition**

* Apply maleic hydrazide (Royal MH-30) at 2 lb aia when bulbs are fully mature with soft necks and 5 to 8 green leaves, or when approximately 50% of the tops have fallen, but are still green. Should be applied at temperatures below 80 to 85 F to avoid crystallization on leaf surfaces.
* Use of a spray adjuvant is suggested in arid regions west of the Rocky Mountains.
* Avoid early sprays before maturity to reduce sponginess. Do not treat seed shallots.
  1. **TOMATO**

**Description of the crop**

*(Lycopersicon esculentum* Mill.) (2n = 24)

Tomato is the most important warm season fruit vegetable grown throughout the world. Tomato is the most important warm season fruit vegetable grown throughout the world. Fruits are eaten raw as salad or cooked and are used in the preparation of products like sauces, pickles, puri, paste, syrup, ketchup and Gianyother items. Tomato still remains as a choice crop of scientists because its short duration nature, easiness in cultivation, large number of seeds in a fruit, easiness in hybridization and cytology works and everlasting consumer demand. Tomato is originated in Peru of South America and name of crop came from the azetc word "Tomatl".

**Ecological Requirement and planting**

* Tomato is a day neutral warm season crop which cannot tolerate frost.
* Cool and dry weather is preferred by the crop and optimum temperature is 21-28 °C during day and 15-20°C during night.
* Night temperature is more critical than day temperature.
* High temperature results in exerted stigma, dryness of stigma, burning of anther tip, poor pollen dehiscence, low pollen viability and slow pollen tube growth leading to low pollination and fruit set. Incidence of viral diseases also will be more at high temperature.
* Optimum temperature for colour development of fruit is 21-24 ° C. Development of colouring pigment, lycopene will be hampered above 27°C. Seed germination and pollen germination are adversely effected below 100 C.
* Tomato cannot withstand water logging. Hence well drained fairly fertile soil rich in organic matter is preferred. It is moderately tolerant to acid soil having pH 5.5 and ideal pH requirement is 6-7.

**Planting**

* Under mild climatic conditions, where there is no danger of frost, three crops can be raised in a year. Tomato seedlings require 5 to 7 weeks at 65 to 75 degrees F day and 60 to 65 degrees F night temperatures to be ready for transplanting to the field.
* If necessary, it is usually possible to use older or younger transplants successfully

**Main field preparation and transplanting**

* Seedlings are transplanted on raised beds or on sides of ridges. Field is ploughed 4-5 times and raised beds of 80-90 cm width or ridges and furrows are prepared.
* Spacing depends on the growth habit (determinate, indeterminate or semi determinate) of variety and various spacing followed are 60 x 30-45cm, 75 x 60cm and 75 x 75cm.
* Usually closer spacing results in early and higher yield, but it may affect size of fruits.

**Fertilization and irrigation**

**Fertilization**

* Manure and fertilizer recommendation for tomato depends on the growth habit and productivity of variety and it varies from state to state.
* In most cases 15-20 tones of FYM, 100-125 kg N, 50-60 kg P20S and 50-60 kg K2o are recommended for one hectare.

**Irrigation**

* Furrow irrigation is the most common method in tomato and the crop require adequate moisture throughout growth period.
* Frequency of irrigation depends on the climatic and soil conditions. During summer, crop should be irrigated at 3-4 days interval.
* Water stress **at flowering** stage will adversely effect fruiting and productivity. A long spell of **drought followed by heavy irrigation** leads to cracking of fruits. Similarly a **dry spell after regular irrigation** causes blossom end rot.
* Drip irrigation and sprinkler irrigation are becoming more common in areas of water shortage.

**Training and pruning**

* **All indeterminate** varieties are trained with wires, strings or stacks to prevent lodging and loss of fruits by coming in contact with soil.
* It is done by providing individual stack or by erecting 2-2.5 m long poles on either side of ridges for stretching GI wire. Branches of plants are supported on poles or strings with twine.
* Pruning is also generally followed in indeterminate varieties to improve **size,** shape and quality of fruits. It is removal of unwanted shoots to enhance vigor of plants

Pest and diseases of Tomato

* Major diseases of tomatoes :

damping off, [anthracnose](http://ohioline.osu.edu/hyg-fact/3000/3114.html), [bacterial canker](http://www.oznet.ksu.edu/dp_hfrr/extensn/problems/baccank.htm), [bacterial speck and bacterial spot](http://ohioline.osu.edu/hyg-fact/3000/3120.html), [buckeye rot](http://www.ext.vt.edu/pubs/plantdiseasefs/450-704/450-704.html), [early blight](http://ohioline.osu.edu/~ohioline/hyg-fact/3000/3101.html), [Septoria leaf spot](http://www.ext.vt.edu/pubs/plantdiseasefs/450-711/450-711.html), [late blight](http://ohioline.osu.edu/~ohioline/hyg-fact/3000/3102.html), [*Sclerotinia* stem rot](http://www.ces.ncsu.edu/depts/pp/notes/oldnotes/vg4.htm)

* Major insect pests of tomatoes :

[cutworms (variegated and black)](http://www.ipm.ucdavis.edu/PMG/r783301511.html), [Colorado potato beetle](http://www.oznet.ksu.edu/dp_hfrr/extensn/problems/colpotat.htm), [tomato and tobacco, hornworm](http://www.ipm.ucdavis.edu/PMG/r783301111.html), [cabbage looper](http://www.ipm.ucdavis.edu/PMG/r783300811.html), [tomato fruitworm](http://www.ipm.ucdavis.edu/PMG/r783300111.html), [tomato psyllid](http://www.ext.colostate.edu/pubs/insect/05540.html), [aphids](http://www.ipm.ucdavis.edu/PMG/r783300711.html), [mites](http://everest.ento.vt.edu/~idlab/vegpests/vegfs/spidermites.html), [flea beetles](http://www.ipm.ucdavis.edu/PMG/r783301411.html), [stink bugs](http://www.ipm.ucdavis.edu/PMG/r783300211.html), [whiteflies](http://www.ipm.ucdavis.edu/PMG/r783301211.html), [wireworms](http://www.ipm.ucdavis.edu/PMG/r783301311.html)

Fig. 5

**Harvesting and packing**

**Average time from transplanting to harvest**

Early cultivars: 50 to 65 days.Mid-season cultivars: 70 to 80 days. Late cultivars: 85 to 95 days

**Yield:** Open pollinated varieties =20-25 t/ha. FI hybrids 50 t/ha.

**Grading, storage and marketing**

* Fruits after harvesting are graded and packed in bamboo baskets or wooden boxes. Since tomato is a climactric fruit, good care should be taken to remove bruised, cracked and damaged fruits before packing in baskets.
* Though tomato can be stored at low temperature, commercially it is not stored in cold storages in the country due to practical reasons.
* Fruits can be stored for two weeks and four weeks at 10-13°C when harvested at red stage and green stage respectively.
* Pre-cooling of fruits before storage and transportation enhances storage life.

**PART II**

**HIGHLAND FRUITS (APPLE)**

# INTRODUCTION

Apple is a temperate climate fruit. The leading apple growing country is China, producing about 41percent of the world's apples, followed by the United States. The tree naturally grows between 5m and 12m tall. The leaves are arranged alternately along the shoot. Their shape is a simple oval. The leaf is 5 to 12cm long and 3 to 6cm wide attaching to a 2-5cm long petiole with an acute tip. The flowers have five petals with a size approximately 3cm. The color of the flowers is white with a pink tinge. The fruit contains five carpals arranged in a five point star. Each carpal contains 1 to 3 seeds. The main shape types are: roundish, oblate, conical, and oblong. Roundish indicates that the height and diameter of the fruit are nearly equal. Oblate indicates that the height is much less than diameter. Conical, is when the fruit is roundish, having the apex end contracted. Oblong, is when the fruit is longer than broad, and having the apex and base of nearly the same breadth. Truncate conic, is when the fruit is flattened at the apex.

Fruits have a lot of nutritional elements, anti-oxidants, vitamin C and dietary fibers, which inhibit cancer-inducing substances. These also contain K which promotes Na release for maintaining blood pressure. The Japanese government has published guidelines, stating the importance of eating at least 200 g of fruits everyday for good health. This standard can be fulfilled by eating either one piece of apple or a cluster of grapes or 40 pieces of cherry or one piece of pear or 7 pieces of prune or 2 pieces of orange a day.

**Why eat fruits?**

* Nutrients – vitamins and minerals
* Fiber – reduce colon cancer
* Fruit pectins – reduce dietary cholesterol
* Phytochemicals – reduce the risk of cancer

Apples have become the symbol of wholesomeness: “An apple a day keeps the doctor away” is a favorite aphorism, and apple pie has become a symbol of goodness along with motherhood.

# APPLE PROPAGATION

**Rootstock propagation**

These rootstock cultivars, which can affect the vigor, habit and cropping performance of scions as well as adapting the scions to unfavorable environmental (edaphic and climatic) conditions, are now used for tree propagation in the majority of apple-producing countries of the world. Their propagation, by stooling, layering or cutting techniques (see fig. one)

* Weak growing (Dwarf): M27, M9, M26 – Height: Between 1.8-3.0 m
* Medium-strong growing: MM106, M7, M4, MM104, M2 – Height: Around 4.0m
* Strong growing: MM111, MM109, M10 – Height: Between 4.8-5.5m

**Rootstock selection** – is the root system and base of the tree on which the fruiting top or scion cultivar is grafted:

* Controls plant size
* Improve plant vigor
* Resistance to certain soil pests and diseases
* Enable plants to tolerate poorly drained soil condition

**MM.106 type rootstock**

**Malling-Merton 106 (MM.106):** A rootstock, slightly larger than M.7, that produces freestanding, early-bearing trees. Trees on MM.106 are susceptible to collar rot when planted in wet soils and are not recommended for poorly drained sites. Delicious on MM.106 is susceptible to apple union necrosis.

Young plants remain attached to the mother plant until they have formed roots and are able to develop independently. Stooling and layering are long-established methods of division (Knight *et al.*, 1928; Anon., 1963) and are still the most common propagation methods for apple rootstocks (see fig. two).

**Stooling**

With stooling (stool or mound layering), 1-year-old rooted plants are planted vertically in spring and left unpruned for 1 year. In the following spring, the stems are cut back to 2–3 cm above the ground and the arising shoots are partly covered with earth several times during the growing season.

To allow earthing up, distances between rows of stools should be adequate – at least 1 m. Within the rows, stools are spaced 30 cm apart. When the young shoots are about 10–15 cm long, friable soil is carefully drawn up to the rows and in between the plants, so as to cover up shoots to half their total lengths. A second earthing up is done when the shoots are approximately 20–25 cm long and a final one when shoots have grown to about 45 cm. After this final cultivation, 15–20 cm of the shoot bases should be covered with soil and it is there that the rooting takes place. The number of times that shoots are earthed up varies and depends on local practice (see fig three).

After natural leaf drop, the ridge of soil or other substrate is ploughed and/or forked away and the rooted shoots are cut loose from the parent plants. Depending on the climate, the removed soil or substrate is raked back over the stools after harvest to protect them from winter injury. The above cycle of production is repeated annually and, provided that no diseases or pests interfere, the stock plants should continue to produce rooted shoots of adequate quality for at least 15 years. Very small rootless plants are usually discarded.

**Layering**

One-year-old plants are planted in rows, which are preferably north–south-orientated, at an oblique angle of 30–40° to the horizontal and left un-pruned for one growing season. The following spring, the stems are bent and secured flat to the ground and the shoots that arise on these horizontal layers are regularly and carefully earthed up, just as with stooling (see fig four).

The plants are planted obliquely at 30 cm spacing in the rows, which are 75–100 cm apart. For establishment, plants with a stem diameter of 8–10 mm measured at ground level are used. After one growing season, the plants are forced horizontally by braiding (tying) them together, including any side-shoots that may have arisen. Given the close planting distance in the rows, there is an overlap of shoots from adjacent layers that facilitates braiding and contributes to high production. The first earthing up is carried out when the shoots are 20–25 cm long and either soil or peat mixtures are used. The peat is brought into the rows using machines, but handwork may be needed for distributing soil or peat evenly between the shoots. At intervals of approximately 1 month, two further earthings up are undertaken. On these occasions, soil is usually used and the shoots are partially covered to leave half of their lengths exposed. In practice, 20–25 well-rooted plants of more than 5–6 mm basal stem diameter per metre of row length can be obtained, plus 15–20 plants that are too thin for immediate use as liners (less than 5–6 mm diameter).

These thin rootstocks are planted for another year at close spacings (10 cm in rows 50 cm apart) in a waiting bed. Plants over 9 or 10 mm in diameter are used for bench grafting.

**Rootstock scion propagation**

**Budding**

Two techniques of budding, T- and chip budding, are used for propagation of apple trees. In both techniques it is essential to achieve effective joining of the cambial layers of the scion bud and the rootstock and to prevent desiccation.

In T-budding, a T-shaped incision is made in the rootstock rind at the time in summer when the bark easily slips from the underlying xylem to facilitate bud insertion. An upper transverse cut is made first, about 1 cm long. A second, vertical cut of about 2.5 cm is made upwards, such that it meets the first one at its middle point. The bud graft is a thin, narrow, oval-shaped piece of bark including a central bud and with some wood tissue on the inside. Holding the bud stick by the upper end a cut is made beginning about 1 cm below a bud. Thereafter, the knife is moved shallowly upwards beneath the bud to about 2.5 cm above it. The shield is then torn from the stick leaving a bark strip that facilitates insertion. After insertion, this strip is cut away and the two rootstock bark flaps are bent back over the bud graft (Anon., 1963; Hartmann *et al.*, 1990) (see fig five).

**Bud wood**

Shoots with flower buds are discarded. After collection, all leaf blades and stipules are quickly removed to prevent dehydration.

Leaf petioles are usually left intact at this deleafing to facilitate bud insertion and as a later indicator of success or failure of bud take. With successful bud take the petiole drops off, whereas it withers and stays on where a bud does not unite with the rootstock.

However, petioles can also be removed with the blades, because the above advantage is considered of minor importance by some nurserymen.

After leaf removal, the shoots of bud wood should be used as soon as possible. In cool and moist conditions, they can be stored for up to 1 week, but it is better to always use freshly harvested material where possible.

**Rootstocks, budding height**

To be suitable for budding, rootstocks should be neither too thick nor too thin. Preferably, the two classes are planted in separate blocks as they may render trees of different quality. Budding is done at least 10 cm above ground level to prevent scion rooting later in the orchard, but 15 cm is a better standard. For special purposes, such as increasing dwarfing or alleviating problems of disease, budding height is higher. For growth control of vigorous scion cultivars, even on dwarfing rootstocks, such as M.9, heights of 25–35 cm are often preferred.

After budding, the rootstock is not pruned until next spring to keep the bud graft dormant. In spring, the rootstock part situated above the bud is cut off either completely or in stages.

**Grafting**

Grafting is made indoors during the winter season. The main method used is the whip-and-tongue graft (Garner, 1979; Hartmann *et al.*, 1990). In order to economize on costs for propagation material, the grafts are short, bearing only two buds. With whip and-tongue grafting, the diameter of the stem of the scion and the rootstock should be about equal. When the rootstock is thicker, side-grafting is used, although it is known that the union of the two partners is less strong than with a whip-and-tongue graft.

After grafting, the two partners are firmly tied together with a plastic strip and the apical end of the graft is sealed with grafting wax (see fig. six).

**Hardening**

Another factor that contributes to the occurrence of winter injury is the variation in temperatures before the cold event. A freezing event preceded by a warm period is far more damaging than continuously cold temperatures.

The development of hardiness is a gradual process that proceeds over a period of weeks, but even a temporary warm period late in winter can lead to rapid loss of hardiness. For this reason, winter injury to apple trees is more common in winters with wide temperature fluctuations than in winters with comparably low but continuously cold temperatures.

**Defoliation and Digging Up (Lifting) Trees**

It is customary to dig up apple trees from the nursery in autumn, after all shoot growth has stopped and most leaves have abscised.

Trees with leaves still present desiccate and are damaged after lifting. In areas where cold nights in early autumn prevail, natural leaf abscission occurs satisfactorily with most cultivars. However, in maritime climates with mild autumns coupled with relatively warm nights, some cultivars do not shed their leaves easily. In these cases, laborious hand defoliation is needed before trees are lifted. Many efforts have been made to find safe chemical defoliants (see fig seven). Ideally, they should not damage the tree and not adversely affect growth in the next season (Miller, 1988).

# SELECTING APPLE ORCHARD SITE

Apple is classified as a temperate fruit tree, which indicates that it is deciduous and requires an extended cold period (chilling requirement) for buds to break for both foliation and flowering. Apple trees can survive in many parts of the world, but most are grown between latitudes 30° and 50° north and south. The primary limiting factor in apple production at latitudes lower than 30°, north or south, is the lack of adequate chilling in winter to break rest (endodormancy). Additionally, the excessively warm temperatures at such latitudes have negative effects on fruit colour and quality. At greater than 50° latitude, north or south, the major limitations related to temperature are damage by the coldest nights of winter and inadequate length of growing season.

At all latitudes, there are sizeable effects of other factors, such as elevation and proximity to large bodies of water.

**Elevation**

Generally, as latitude decreases, commercial apple orchards are planted at higher elevations. Proximity to oceans or lakes Bodies of water serve two vitally important roles in minimizing frost damage. In the spring, water warms up more slowly than the adjacent land surfaces. The prevailing winds are cooled as they pass over the cold water in the spring. As the cooler air passes over the adjacent apple trees, bud development is delayed, thus decreasing the probability of spring frost injury. In the autumn, the water cools more slowly than the land and thus air masses are warmed as they pass over it. This warmer air delays the onset of early-autumn freezes. This lake effect is of consequence for only a few kilometers from the lake but accounts for the large concentration of orchards and vineyards along the leeward sides of lakes or other large bodies of water.

**Chilling requirement**

Other than on very young trees, vegetative growth of apples is complete after about 2–3 months, with the formation of terminal resting buds. Although these buds can be induced to grow again in the current season by defoliation, they lose this ability as the trees pass into autumn. This ability to start growth following defoliation is used to prevent the tree entering dormancy in some areas of the subtropics, where there is inadequate chilling; in this context the trees will flower after defoliation and the trees can bear fruit twice each year. In temperate regions, however, the buds become dormant and will not begin growth until a period of winter chill is followed by warmer conditions in the following spring.

The apple is a fruit tree in the general category of temperate plants, which are characterized as requiring an annual cold period to satisfy their ‘chilling requirement’. If the chilling requirement is not satisfied, the buds will not open; if the chilling requirement is partially met, the buds will open sporadically and both the bloom and harvest periods will be abnormally extended. Most apple cultivars require between 1000 and 1200 h of chilling in the range of 4–7°C. Temperatures below 0°C or above about 10°C do not provide chilling and may actually negate previously accumulated chilling hours. Because of this, the chilling requirement of a particular cultivar may well be satisfied earlier in middle latitude than in a more pole ward latitude.

In some parts of the world where winter temperatures are so warm as to barely meet the chilling requirement (as in parts of California), the presence of frequent morning fog delays the daily rise in temperature of buds, thus enabling the accumulation of adequate chilling hours.

In warm areas where the chilling requirement is not met, rather extreme treatments can induce the buds to grow despite the lack of chilling (Edwards, 1987). According to Janick (1974), cultivars including ‘Rome Beauty’ and ‘McIntosh’ as well as local cultivars can be grown in areas of Indonesia (east Java) at latitudes of less than 10°S and elevations of 700–1200 m. The maximum, minimum and mean annual temperatures are 31, 22 and 26°C, respectively. Through the use of complete defoliation approximately 1 month after harvest, a new growth and fruiting cycle is initiated. Flowering occurs approximately 1 month after the trees are defoliated. The cycle is repeated to induce two crops per year. In subtropical regions, the chilling received is inadequate and various treatments have been developed to supplement the chilling received. In addition to the selection of low-chilling cultivars, such as ‘Anna’ and ‘Ein Shemer’, several chemicals have proved to be at least somewhat effective.

These include mineral oil, dinitro-*o*-cresol, potassium nitrate, thiourea and cyanamide, as well as gibberellins and cytokinins (Erez, 1987).

**Length of growing season**

The number of days from blossoming to harvest for apple cultivars ranges from 75 or 80 to over 200. Short-season cultivars can be grown widely, but those requiring more than 180 days are restricted to regions with long growing seasons.

**Radiational freezes**

Most important is its elevation, not above sea level but above the adjacent terrain. The vast majority of frost damage occurs under radiational freeze conditions.

On relatively clear, calm, spring nights, heat is lost by radiation from plants, soil and other surfaces exposed to the cold sky. The lower layers of air are cooled by losing heat, by conduction, to these exposed surfaces, which have dropped below air temperature. As air is cooled, it becomes denser (heavier) and therefore settles on the ground, flowing ultimately into low areas; this settling of cold air has led to the term ‘frost pocket’, used for low-lying areas that are particularly subject to frost damage.

**Root injury**

The roots of apple trees are considerably less cold-hardy than are the above-ground portions. Much of this difference is because roots do not go into rest and are active during winter when soil temperatures are above a minimum of about 6–7°C. Secondly, since roots are not exposed to temperatures as low as are the above-ground portions, they do not develop nearly as much hardiness. If an apple root is exposed to the same gradually declining temperatures as the above-ground parts of the tree, the hardiness of the root can become equal to that of a branch.

# SOIL CONSIDERATIONS AND SITE SELECTION

**The textural**

Grouping influences several soil properties important to apple production, including potential water-storage capacity, perviousness to internal water transmission, aeration and nutrient-exchange capacity.

Serious growth problems can arise when compacted layers with high bulk density and associated reductions in air-filled voids occur in the main rooting zone.

**The depth**

Of unrestricted root penetration by apple can be quite variable, with a 1–2 m depth most common, although most roots are generally located within the surface 0.8 m depth (Atkinson, 1980). A greater potential rooting depth can enhance tree growth and production by increasing tree access to nutrients and water. This can be particularly important in coarse-textured soils, which often have limited nutrient- and water-holding capacities. Shallow soil depths can be less limiting to apple tree performance for scions on rootstocks that are already naturally dwarfing.

**Flat or gently**

Sloping sites are ideal for the operation of equipment. Other considerations include location with respect to prevailing winds and local air flows. Exposed ridges and narrow valleys subjected to persistent strong winds can result in disruption in the timing and accuracy of spray application and can even distort tree shape.

An ideal soil pH range (as measured in water) for apple is 6.5–7.0, although there has been limited documentation of this information. It is, however, known that below pH 5.5 the solubility of manganese and aluminum ions increases rapidly in most soils. Manganese toxicity has been associated with internal bark necrosis and reduced vigor of newly planted trees (Hoyt and Neilsen, 1985).

**SITE PREPARATION**

**Tillage**

Sometimes mechanical manipulation of soils 15–25 cm below the normal tillage depth is warranted. These activities, also referred to as deep ploughing, chiselling, subsoiling or ripping, are intended to break up any compacted or impermeable layers within the root range of young trees. This should increase infiltration and pore size for drainage and water storage, allowing improved root growth and leaching of excess water and salts. It is physically much easier to plant into soils after deep ripping (see fig. eight).

**Contouring**

Where water runoff and soil erosion concerns are great, orchards can be established parallel to contours, so that orchard operations can be undertaken as nearly as practical on the contour.

**Terracing**

Terracing is usually considered an extreme form of land shaping. Although practiced for thousands of years in many parts of the world to conserve moisture and reduce erosion, establishment costs are high.

**Drainage modification**

The benefits of improved soil drainage can allow successful production of apples on soils and in locations where water logging and poor aeration would normally limit the development of orchards.

**Row orientation:** Results from several researchers indicate that, in general, a north–south row orientation provides both better light interception and a more even distribution throughout the tree canopy than an east–west row orientation and is therefore preferred (Cain, 1972; Jackson, 1980) (see fig. nine).

**Placement of Pollenizers:** With the widespread utilization of the hedgerow design, a commonly accepted practice is to place pollenizer trees (often flowering crab apples) about every 15 m in each row and to offset the pollenizer trees in adjacent rows.

Particularly with very dwarfing rootstocks, no space is allocated to the crab apple pollenizer trees. They are set between adjacent fruiting trees and are trained to a tall cylindrical shape. Since crab apples flower so profusely, the severe pruning that is required does not restrict flowering. Among the advantages of crab apples as pollenizers are their annual flowering without the need of thinning, no mix-up of fruit at harvest and a wide choice of flowering time to match most cultivars.

# TREE PLANTING AND DEVELOPMENT

The saplings should be planted if the soil not too wet. First open a large hole to accommodate the root system. Before planting, any roots that are broken or kinked should be cut off. A planting board can help positioning the sapling on the top of the hole. Replace the planting board with the tree stem fitted into the central notch with the graft at least 5-10 cm above the soil surface. After that, fill the hole with soil until the root ball is fully covered. Gently firm the soil around the tree and level the soil. The tree should be planted to the same depth as it was in the pot (or the soil mark on the trunk in the case of bare-rooted trees). Water well if the conditions are dry (see fig 10).

**Planting depth**

After the tree has settled and the soil in the planting hole has consolidated, the bud union should be 4–6 cm above the soil surface; this means that when initially planted, the bud union should be 6–8 cm above the soil surface.

**APPLE DEVELOPMENT**

**Trunk cleaning**

Shoots may arise from the trunk in positions where they are not wanted. In the final year of the growth of 1-year-old trees, shoots originating lower than 40–50 cm above the soil are unwanted. If retained and allowed to develop, fruits borne on such branches hang too close to the ground and are thus difficult to pick and prone to rot because soil fungi may splash up with soil particles during rain. Laterals that are too low are rubbed away when still only a few centimetres long. By doing this early, wounds are small and heal easily. This measure may slightly favour the formation of higher laterals and has no negative effects on trunk size or tree height (de Groene, 1986). With snip and interstem tree raising, shoots below the preferred terminal shoot are also rubbed away, but in stages, with time intervals between each removal in spring and early summer, to prevent bleeding.

**Flowering, Pollination and Fruit Set and Development**

Flowers are the ‘raw materials’ for fruit production. Therefore heavy flowering is essential for economic success. But, unlike the situation with floriculture crops, flowers alone are not sufficient. They must set fruit and the fruit must mature and be of sufficient size and quality to be marketed at a profit.

**Juvenility**

Flowering can be induced in the second year in some cases, but only buds near the top of the tree flower; there appears to be an effect of ‘distance from the roots’, suggesting that inhibitory compounds (gibberellins (GAs) ?) produced in the roots move up the stem and prevent flowering. If the distance between roots and buds is sufficient, the concentration of these compounds is too low to be inhibitory. This hypothesis is questionable, however, because buds taken from a juvenile tree will not flower when grafted into the top portion of a bearing tree. Propagation on dwarfing rootstocks reduces the time to flower considerably, with most dwarf trees flowering within 2–3 years.

**Pollination**

Most apple cultivars require cross-pollination to set commercial crops of fruit (i.e. are self-unfruitful) and, even in partially self fruitful cultivars, such as ‘Rome Beauty’, ‘Jonathan’, ‘Yellow Newtown’ and ‘York Imperial’, cross-pollination is recommended.

Cross-incompatibility (i.e. both cultivars produce viable pollen, but neither will set fruit when cross-pollinated) occurs in very few combinations, such as ‘Early McIntosh’ ‘Cortland’. However, triploid cultivars are a more common problem, as their pollen has low viability. The haploid number in apple is 17; hence triploids have 51 chromosomes.

Therefore, the chromosomes are unequally divided – or parts of them may occur in the haploid cells – during meiosis. Such cultivars (e.g. ‘Winesap’, ‘Mutsu’ (‘Crispin’), ‘Jonagold’) are ineffective as pollinizers for other cultivars.

In addition to being compatible, pollinizers must bloom at the same time as the cultivar being pollinated and should be annual, rather than biennial, to ensure a supply of pollen each year. Nursery catalogues often contain compatibility charts, providing growers with information as to which cultivars are suitable as pollinizers.

Pollen can be purchased from commercial companies and used in inserts placed at the entrance of honey bee (*Apis mellifera* L.) hives. Bees exiting the hive unwittingly pick up pollen and carry it to the flowers visited. Pollen can also be ‘dusted’ on trees by dropping it into the draught created by an air-blast sprayer. Some growers use helicopters to apply pollen from the air, after mixing it with a suitable diluent. However, the ‘target’ (stigmata of the flower) is very small; thus much pollen is wasted. As a last resort, flowers can be pollinated by hand, but the labour cost is high, even though only one or two flowers in several clusters need be treated.

Apple pollen is heavy and is not carried readily by the wind as is the pollen of some tree species, such as conifers and nuts. The pollen is transferred primarily by insects, especially honey and bumble (*Bombus* sp.) bees. During bloom, prolonged periods of cool weather or rain, which limit bee flight, can be detrimental to fruit set. Fruit growers rent honey bees from apiculturists during the bloom period, a minimum of four or five strong colonies per hectare being recommended in mature orchards. The bees must be removed from the orchard prior to application of insecticides.

**Fertilization**

Once compatible pollen grains have been deposited on the stigma, they germinate and the resulting pollen-tubes, each containing three nuclei (tube nucleus and two generative nuclei), grow down the style into the ovary. One tube enters the micropyle and penetrates the ovule, where it ruptures, releasing the two generative nuclei.

One of these unites with the egg cell to produce the diploid zygote and one unites with the two polar nuclei in the embryo sac, producing a triploid nucleus. The zygote divides rapidly to produce the embryo, while the triploid nucleus divides to form a free-nuclear, liquid endosperm.

**Fruit Development**

Soon after fertilization occurs, the ovary and surrounding receptacle tissues begin to grow and the fruit has set. However, flowers in which fertilization did not occur soon fall and many developing fruits abscise before reaching maturity. Most abscission occurs within the first 4–6 weeks of growth, culminating in the ‘June’ drop (see fig. 11).

# CLIMATIC REQUIREMENTS OF APPLE

**Light**

The first and foremost concern for the apple grower must be to ensure high levels of light interception in the orchard, coupled with homogeneous distribution of light throughout the tree canopy. This is achieved by N–S orientated rows, with trees trained to forms that have a high area/volume ratio, i.e. which are thin and have a high proportion of the foliage exposed to the incoming radiation.

Generally light should be:

* As much sun as possible to bear heavily and ripen their crops
* Needed for photosynthesis and color formation
* Six hours of direct sun per day is considered minimum for average fruit production
* Day-length determines when some fruit crops flower
* Poor light: flavor, color, flesh quality

**Temperature**

Temperature has profound effects on all aspects of apple production. First, it sets boundaries on production areas. Being basically a temperate deciduous species, the cultivated apple needs a period of winter chill to break dormancy. Secondly, temperature controls the length of the growing season, which in turn limits the range of cultivars that can be grown in any one location. Thirdly, temperature alters the rate of development of all physiological processes, including key processes such as the rates of pollen tube growth, cell division and respiration. Fourthly, temperature alters the development of apple pests and diseases so that warmer areas frequently have more generations of pests than cooler ones.

**Freeze Injury**

Although, when fully dormant, apple trees can withstand \_38°C, once dormancy is broken and active growth has begun, flowers are very sensitive to low temperatures and can be killed by late spring frosts. The critical temperature for damage to the tissues decreases as the flower buds develop, although some minor hardening is possible if the flowers have been exposed to low temperatures and dry conditions prior to the frost event. Within the apple flower, the styles and ovules are more sensitive to damage than the surrounding tissues.

By far the most economical way of avoiding frost damage is to select sites that, due to location, slope and aspect, have a low risk of spring frosts, coupled with good cold-air drainage. There are, however, a number of physical steps that are used to reduce or eliminate late-spring frost damage, all of which rely on the supply of heat to the sensitive tissues.

**Fruit Quality**

Although fruit colour development on red cultivars of apples is strongly dependent on cultivar, fruit maturity, light, nutrition and crop load, there is also a pronounced effect of temperature (Saure, 1990). In general, cooler night temperatures favour the development of red colour.

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# APPLE FERTILIZATON AND IRRIGATION

The nutrient availability of the soil depends on the soil pH. The farmer should adjust the soil pH

between the following ranges:

Topsoil: Between 6.5 and 7.0

Subsoil: Between 6.0 and 6.5

Tree nutrition is probably the most important factor for successful orchard management, and it can be controlled through proper fertilization practices. The fertilization program is focused on two factors. First, during the initial phase, the adjustment of soil nutrient status is the focus. Secondly nutrients may need to be replaced if they were removed from the soil by the tree. Part of the nutrients accumulates in the “body” of the tree and a large amount of nutrients are removed by the fruit yield.

**Generally proper management of nutrients:**

– Tree crops are normally fertilized yearly on precautionary basis

– Rate is based on soil and tissue analysis

– Use of OM, cover crops and green manure

*Table 1 Recommended amount of manure per fruit tree*

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**APPLE IRRIGATION**

The apple’s water need is high, about 800mm per year. The water use of the tree is divided to three periods. The first period is the increasing water use: This stage starts from bud break and finishes when the tree fully developed the first groups of shoots. The water use increases gradually. If the water availability is not adequate the fruit set not will happen. The second period includes the main water use stage. The water use is the maximum, because the foliar volume is huge and the heat causes the highest evapo-transpiration of the whole growing season. Lack of water in this stage severely affects fruit development and causes the falling of fruits in plum, apricot and peach. Finally, during the third period the water use decreases and the tree turn into the dormant stage.Small holder farmers usually use surface irrigation. Three methods are important: Border, furrow and basin irrigation. The main concepts for irrigation are to avoid over or under irrigating the trees and irrigation application should follow a regular interval pattern (see fig. 12).

# PRUNING AND TRAINING OF APPLE

Proper pruning practices increases the quality and value of the crop. Apple tree must be pruned

every year. The amount and quality of fruit are determined by the relationship between vegetative and generative growth. Excessively vigorous wood can result in fruit loss.

Apple tree needs full sunlight. Shade is a limiting factor for apple fruit development. Large penetration into the canopy of a standard and un-pruned apple tree is gradually decreases with the depth of the penetration. The top canopy layer still will have 60-100% of full sunlight, while the middle layer will have only 30-59%. The lowest layer of the canopy even will be less than that.Therefore pruning is essential for apple fruit growth.

***Principles of pruning apple tree***

Pruning is the most confusing technique for growers. There are many techniques which vary according to the cultivar type, production method, etc. It also requires knowledge, skills and considerable experience. Therefore the first thing to do is to visualize the purpose and goal of pruning.

Although pruning stimulates shoot growth it is also a dwarfing process to reduce tree size. However, pruning will not affect or change the overall growing habit of the tree. This is one of the reasons fruit trees should be pruned annually. Excessive pruning can alter the tree’s balance even if it does not change the tree’s growing habit, and will also stimulate the growth of water sprouts and suckers.

It is important to avoid mistakes that cannot be reversed. The first step is to recognize the difference between fruit and leafy buds. Fruit buds are larger and more rounded than leafy ones. Fruit buds can be located on the tips of the spur and short shoots rather than laterally on the shoots. Lateral shoots mainly contain leafy buds in addition to shoot tips.

The following list contains the main general recommendations for pruning practices (see fig 13):

* If pruning is taken place during the dormant season, the ideal time period is the late dormant Season
* Summer pruning is advised to remove water sprouts, suckers and infected wood.
* Only use wound dressing for cuts that have a diameter more than 4-5 cm
* Prune the upper layer of the canopy more heavily than the lower one
* Prune on a horizontal plane and remove any branches that hang downward or rise straight upward
* To reduce length, it is preferable to use a thinning cut rather than a heading cut, which

causes excessive shoot growth

* Remove all branches with narrow crotch angles (they are always weak branches), crossing branches or upright water sprouts
* Remove all broken, dead or diseased branches on regular basis
* Suggested pruning cuts:
* Suckers
* Stubs
* Downward growing limbs
* Rubbing and crossing branches
* Shaded interior branches
* Competing leaders
* Narrow crotches
* Whorls

**Time of Pruning**

Most pruning on apple trees is done when they are dormant. In areas that can experience very low temperatures in winter, time of pruning is an important consideration because it increases susceptibility to low temperature injury (winter injury). Sensitivity to cold injury after pruning is greatest in the tissue in close proximity to the pruning cuts. The exact temperature required to induce winter injury varies with many factors, such as previous exposure to low temperatures, previous crop, cultivar, rootstock and tree age. Winter injury may occur at low temperatures in the range of \_23 to \_49°C, depending upon the inherent hardiness of the tree and these contributing factors. Pruning within 2 weeks prior to the low-temperature event will increase the sensitivity of the tree to cold injury, with the greatest loss of hardiness occurring within the first 48 h (Rollins *et al.*, 1962). The loss in hardiness is then gradually regained. Thus, the risk of causing winter injury by pruning can be reduced by suspending pruning work when severe cold weather is forecast.

When pruning is delayed until growth starts, the tree responds differently. Delay much beyond bloom devitalizes growth and may interfere with the development of flower buds for the next year’s crop. Pruning cuts at the time vegetative growth is beginning result in an increase in the number of buds that break and buds further from the cut tend to break more when compared with dormant pruning. This response is probably due to the removal of apical dominance since the meristematic regions in the growing buds are primary sources of auxin. Generally the breaks that occur from delayed pruning are less vigorous and may be very desirable on cultivars that tend to have blind wood (previous-season wood with no lateral growth), such as ‘Tydeman’s Red’ or ‘Rome Beauty’. Delaying dormant pruning until bloom can also be used to lessen the regrowth in overly vigorous trees; however, delayed pruning should not be used on trees with less than optimum vigour.

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# PEST AND DISEASE MANAGEMENT

Pest and disease control begins with the use of pest-disease free planting material. The saplings should be healthy with good vigor. Do not buy saplings with unknown origins or without certificates.

Replace chemical control with other methods when possible. It is in this way that the natural enemies of pests can effectively intervene with plant eating insects. Chemical use also kills the benevolent insects too. Tools such as pruning tools should be clean and disinfected frequently. These tools can transfer diseases from one tree to another.

Mechanical control can also help keep the orchard free from pests and diseases. Aphids and mealy bugs can be washed off the leaves with a strong water spray or soap. Larger insects can be picked up and destroyed. A paraffin lamp in a bowl of water is an effective insect trap. Fallen fruits often contain insect’s eggs. Burying these fruit under the fruit trees destroy the eggs.

Spraying dormant trees with chemicals and oil reduces the pest’s population before the growing season starts. When fungicide is added to the pesticide and oil it will destroy over-wintering fungus and bacterial spores. Common practice is for growers to use preventive spraying during a particular development stage of the tree. Farmers always apply one spray at petal fall and then again two weeks later.

**Mildew:** This is characterized by light grey powdery patches appearing on the leaves, shoots and flowers, normally in spring. The flowers will turn a creamy yellow color and will not develop correctly. This can be treated by eliminating the conditions which caused the disease and burning the infected plants are among the recommended actions to take (see fig 14).

**Apple scab:** The fungus that causes apple scab on apples is Venturia inaequalis. Symptoms usually start on the undersides of leaves. Spots, at first, are small, irregular lesions that are light brown to olive green in color. Spots eventually turn dark brown to black. Infected tissue thickens, causing the upper surface to bulge upwards and the lower surface to depress. Leaves may curl and scorch at the margins. If the leaf petioles become infected, the leaves drop early. If the pedicels become infected, the fruits may drop early. Scab on the fruit appears as nearly circular, velvety dark green lesions. The skin of the apple near the infected area margin ruptures. Older lesions are black, scabby, and cracked.

Infections occur during moist conditions. Keep plants vigorous. Remove and destroy infected leaves, flowers, and fruit as soon as possible. Grow resistant varieties when ever possible. The battle against scab is won or lost from bud break to fruit set. This is when scab gets started. A preventive fungicide application should be taken place during this period or during rainy wet weather on more susceptible apple varieties. Once leaves start to yellow and fall off the tree, it is too late to spray for control during the current growing season (see fig.15).

**Fire blight:** Fire blight is a devastating disease caused by the bacterium Erwinia amylovora and is very difficult to control. The disease develops rapidly in early spring during rainy weather and the tree is in bloom. Blossoms and young leafy twigs show the first symptoms, appearing wilted or shriveled and turning brown to black. The tips of infected young twigs wilt and die, forming a shepherd’s crook as the disease moves down the branch. Dead leaves often remain attached to the branch. During wet weather, a milky-like, sticky liquid can be seen on the stems and branches.

To control infected tree remove all infected tree parts and burn them. Pruning cut should be 25-30 cm below the infected part. Disinfect carefully all pruning tools. Avoid excessive nitrogen application. Simple copper hydroxide or copper sulfate application is effectively prevent the disease (see fig. 16).

**Black rot:** The fungus is called Physalospora obtusa (Botryosphaeia obtusa) and it causes black rot. The disease begins on the leaf as a purple speck that enlarges to have a brown or tan center. Heavily infected leaves drop from the tree, which weakens the tree and reduces flowering the next year. Limbs may have slightly sunken, reddish brown areas called cankers. Infected fruits begin with tiny red or purple spots occurring opposite the stem end. After a few weeks the spots enlarge and have alternating zones of black and brown. The rot eventually affects the entire fruit, which wrinkles, mummifies and remove and discard dead branches and diseased fruit, where the fungus can survive during winter. The fungicides captan and thiophanate-methyl are effective if it is applied during early season (see fig 17).

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**Pictures**

For part I



Fig. 1 Well managed potato farm



Fig.2 Bacterial wilt of potato



Fig. 3 Carrot Farm



Fig.4 Beet root farm



Fig. 5 Tomato farm

***For Part II***



***Fig. 1*** *Apple rootstocks distributed widely in the world*

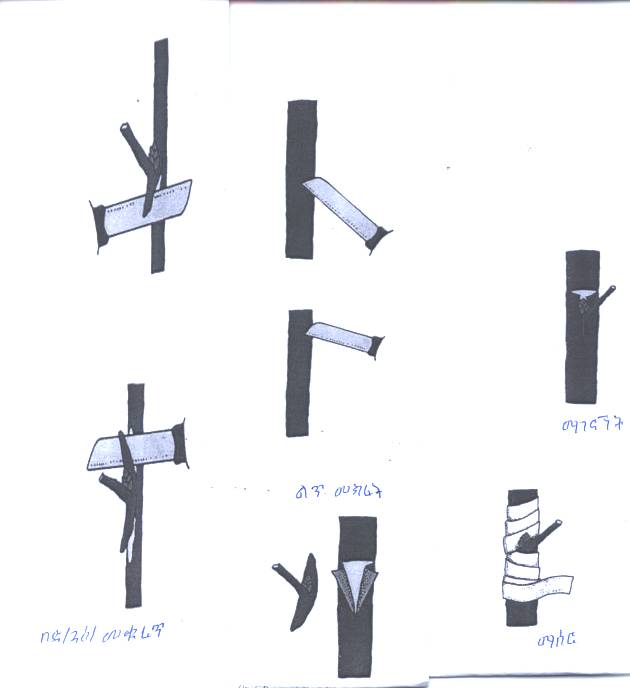
***Fig. 2*** *Indicates apple rootstock production using root and stem cuttings at Chencha*



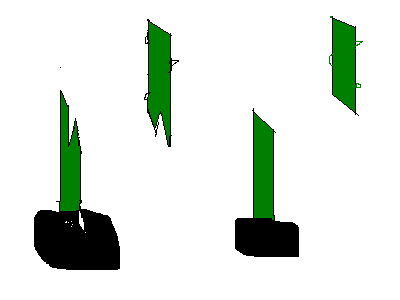
***Fig. 3*** Apple rootstock production using stooling at Dessie



***Fig. 4*** Apple rootstock production using layering at Dessie



***Fig. 5*** *Indicates the propagation of apple using T-budding*



***Fig. 6*** *Indicates the propagation of apple using whip and-tongue grafting*

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***Fig. 7 A****pple seedlings defoliated immediately either after or before up-rooting before distributed to growers to reduce water loss through desiccation (taken from Mekelle University, 2001 EC.)*



***Fig. 8 A****pple planting hole prepared at Kabi during 2004 E.C.*



***Fig. 9 A****pple lay out and orientation at Bededo Tehuledere district (taken from Bededo apple adaptation trial)*

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***Fig. 10 A****pple planting done when the soil is moist and mixed with well decomposed organic fertilizer*



***Fig. 11 three years old young apple three with well developed apple fruits in*** *Wollo university at Dessie Campus)*

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***Fig. 12*** *The removal of excess water using raised bed and watering of apple by harvesting the water during the main rainy season south wollo, Ethipia .*



***Fig. 13*** *All unwanted parts (indicated by letter in the picture below) of the mother tree should be removed frequently using pruning*

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***Fig. 14 Mildew*** *(Wollo University 2003/4 E.C.)*

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***Fig. 15*** *Apple scab (K. Russ, 2007)*